MES SERVICE NOTE

MITSUI ENGINEERING & SHIPBUILDING CO., LTD.
DIESEL TECHNICAL INVESTIGATION GROUP.

for MITSUI－MAN B&W engines		No. 190	
Optimization of the Cylinder Oil Feed Rate based on the Drain Oil Analysis		APPROVED	N. Osako
		CHECKED	
		PREPARED	K. Harada
ENGINE TYPE	All engine types	DATE	2014.3.20

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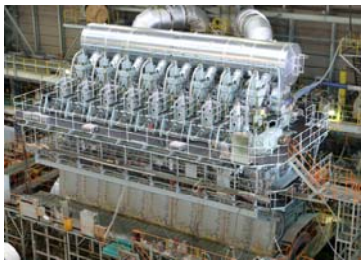
The licensor, MAN Diesel & Turbo announces that one of the ways to evaluate the cylinder condition and optimize the feed rate is to do the stress test, a so-called sweep test. We herewith enclose the procedure of the sweep test.

The sweep test can also be used in the ACC familiarization period to find the suitable feed rate for your particular engines, operating pattern and lube oil used.

Regarding the guidelines on cylinder lubrication on engines equipped with alpha lubricator, please refer our Service Note No.189 for mark8 and newer engines and Service Note No.188 for Mark7 and previous engines.

PRIORITY							
IMMEDIATELY	☐	AT FIRST OPPORTUNITY	☐	WHEN CONVENIENT	■	OTHERS	☐

Mitsui Engineering & Shipbuilding Co. ltd.
Diesel Technical Investigation Group
1-1, Tama 3-chome, Tamano, Okayama 706-8651 Japan
TEL: 0863-23-2534 / FAX: 0863-23-2772
E-mail: demail @mes.co.jp



Sweep Test Procedure for MAN B&W Two-Stroke Diesel Engines
Finding the Optimal Cylinder Lube Oil Feed Rate Factor

Continuous monitoring of drain oil samples is a good way to optimise the cylinder oil feed rate, cylinder oil consumption and to safeguard the engine against excessive wear. The fastest way to evaluate the corrosive behavior of an engine and optimise the feed rate is to do a stress test, a so-called sweep test. It can also be used in the ACC familiarization period to find the suitable Feed Rate Factor (FRF, also called ACC factor) for the particular engine, operating pattern and cylinder oil used. The Sweep-Test Protocol can be found on page 7 and 8.

During the sweep test, the vessel should be running on fuel with sulphur content above 2.7%. The sweep test takes 6 days and should be performed during a longer voyage. The Engine Control System (ECS) load setting should remain constant during the sweep test. The feed rate of the cylinder oil is set to fixed steps and drain oil samples are taken after 24 hours, before lowering to the next step (figure 1).

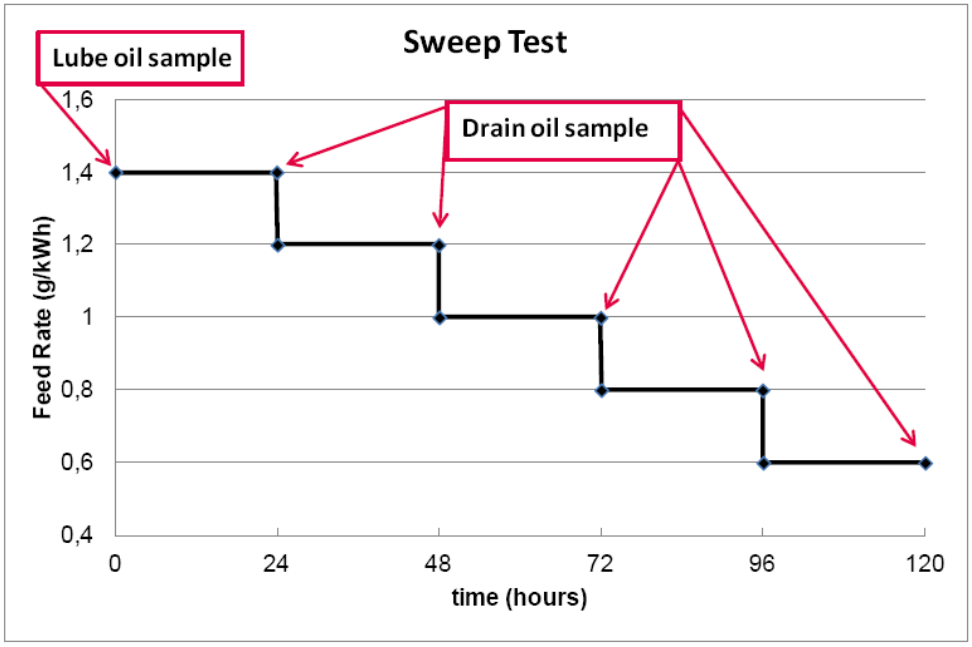


Figure 1. Overview of the sweep test procedure

Samples and analysis methods

Before the test starts, samples of the fuel in use, system oil in use and fresh (unused) cylinder oil should be taken. When the test has been completed, all samples should be sent ashore to a certified laboratory. The iron (Fe) content and the BN value should be analyzed. The Fe content should be analyzed using the ASTM D5185-09 and the BN should be analyzed using the ISO 3771:2011(E) method. The Fe concentration will be the measurement of corrosion and wear. The BN in the drain oil is an evaluation of the performance of the oil and the need for neutralization in the engine. When the results are received, the suitable Feed Rate factor can be established for the particular engine, fuel, and lube oil and operation pattern.

The BN and Fe content of the drain oil can also be measured by various on-board analysis equipment. When measuring Fe with on-board analysis equipment, it is important to choose an instrument that measures the total Fe content. On-board equipment gives fast results, however, we recommend sending the samples to a laboratory in order to secure accurate results.

Test Procedure

Read all the instructions carefully before starting the Sweep test. The Engine Control System (ECS) load setting should remain constant. The sweep test should be carried out above the lubrication breakpoint. In most cases, this breakpoint is at an engine load of 25% (40% MEP load). When the lubricator is below the breakpoint, the cylinder feed rate for each cylinder changes from a number to “low load” on the MOP-screen. A sweep test cannot be started when the MOP screen states “low load”. There are different versions of the MOP-screen and instructions on how to change the Feed Rate Factor (FRF or ACC factor) and the feed rate can be found in the instruction book.

Before starting the sweep test: Normal running condition

Figure 2 shows a MOP-screen under normal running conditions, after the initial running in of the engine, i.e. the first 500 hours. The “Running In” mode should be “Off” (0.00) and the “Feed Rate Adjust Factor” should be “1.00” (= 100%).

In this mode, the fuel oil sulphur content “S%” and the “Feed Rate Factor” gives the “Basic Feed Rate”, which is also shown for each cylinder as the “Actual Feed Rate”. In this example, the S% is 3.20 and the “Feed Rate Factor” is 0.40 g/kWhS%, which results in a “Basic Feed Rate” of 1.28 g/kWh (Figure 2).

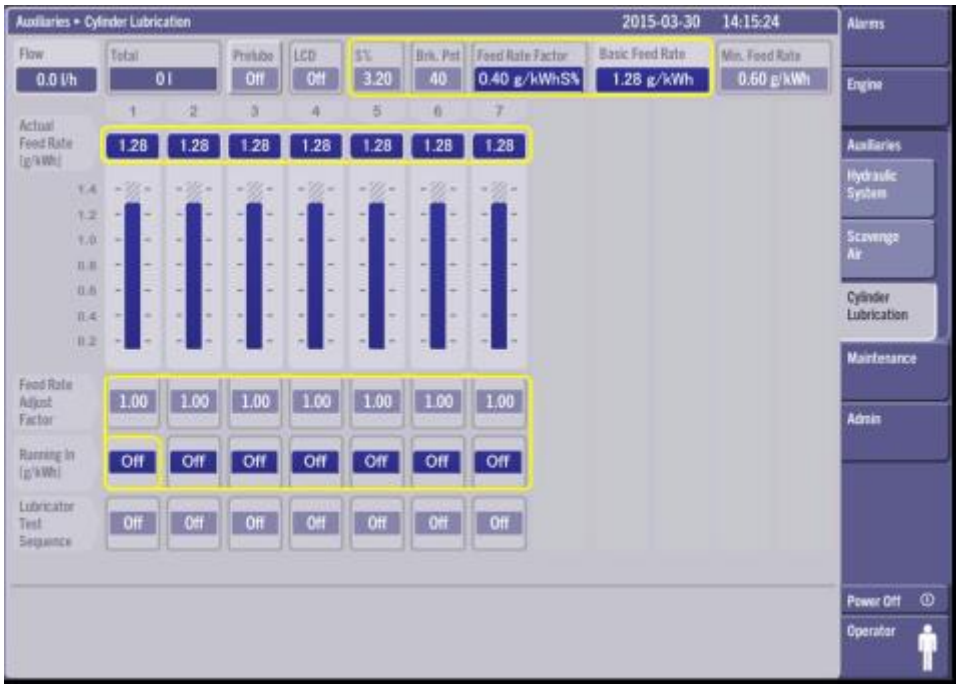


Figure 2. MOP-screen showing settings at normal running conditions. Running-in mode is turned OFF

Day 1: Start of sweep test (at least 24 hours after departure)

When starting the sweep test, the easiest way to set the desired cylinder oil feed rate is to use the “Running In” mode. This mode overrules the normal running mode, as shown in Figure 2. However, the minimum feed rate will never be lower than the “Min. Feed Rate” (here 0.60 g/kWh) even if the “Running In” mode is set to a lower value than “Min. Feed Rate”. For the first 24 hours of the sweep test, the “Running In” setting should be “1.40” g/kWh, as shown in Figure 3.

Note!
On the latest MOP software versions, the highest value of the “Basic Feed Rate” and “Running In” is in control. In this case, the fuel sulphur should be set to 0.1% and the “Feed Rate Adjust Factor” should be “1.00” (= 100%) during the sweep test, **and set back to actual value when the sweep test is finished, see Figure 4 & 5.**

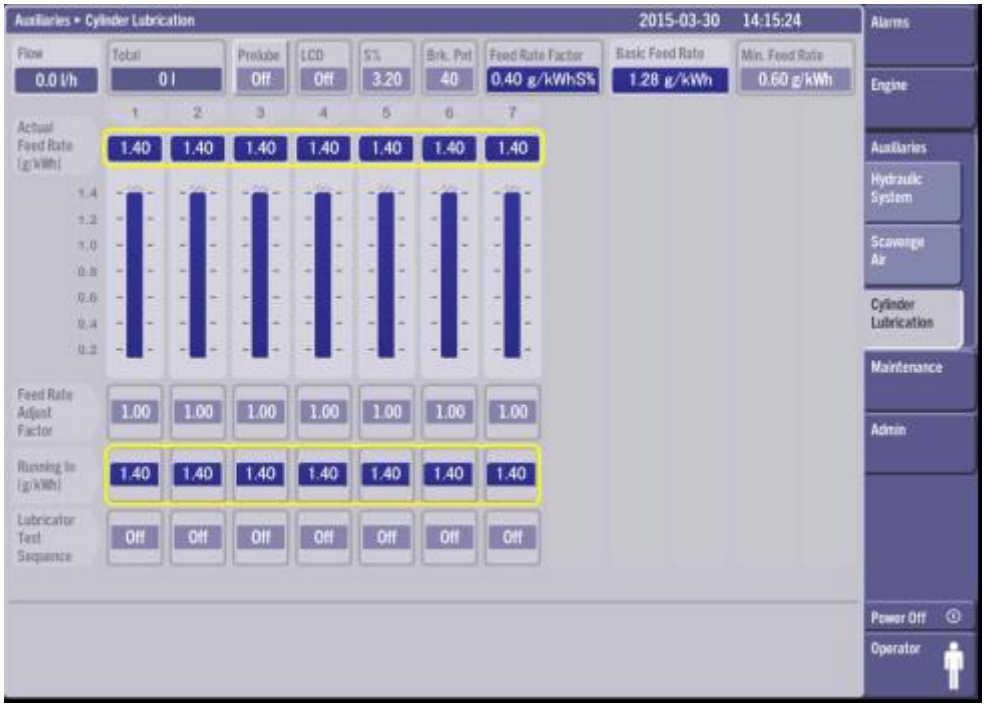


Figure 3. Day 1 of sweep test. The Running In mode is used and set to 1.4 g/kWh

Be sure that the correct cylinder oil is used, and take reference samples of fresh cylinder oil and fuel. Adjust the feed rate of the cylinder oil to 1.4 g/kWh as shown in figure 3. Write down the following information in the sweep test protocol:

a. Name of ship and type of engine
b. Date and time of starting the test.
c. Name and brand of the cylinder oil, BN and SAE viscosity number
d. Engine load

Day 2 Take drain oil samples from all cylinders after running 24 h on a cylinder oil feed rate of 1.4 g/kWh.

Important: Make sure to flush the drain valve into a bucket before taking the sample. Only use clean bottles, and make sure not to mix drain oil form one unit with another. Mark the bottles with the following information:

a. Cylinder no.
b. Date
c. The name and BN number of the cylinder oil
d. Feed rate of cylinder oil
e. Engine load

Also, write down the information in the test protocol. After this, the cylinder oil feed rate should be adjusted to 1.2 g/kWh as shown in Figure 4.

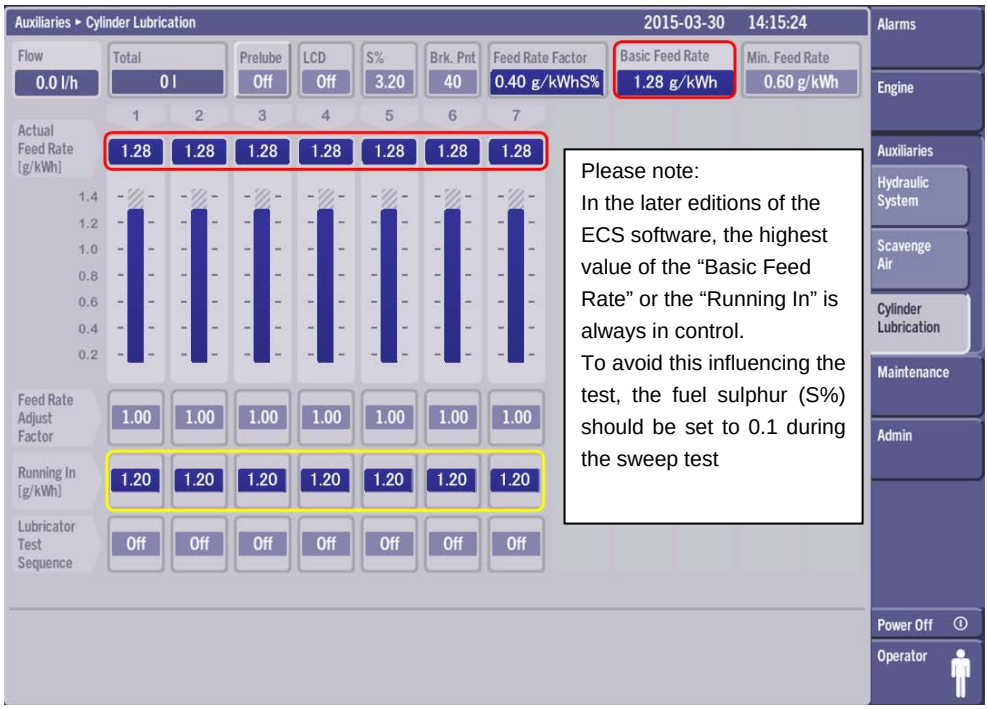


Figure 4. Day 2 of sweep test. The Running In mode is used and set to 1.2 g/kWh, and in this case the “Basic Feed Rate” is higher and over-rules the “Running In”.

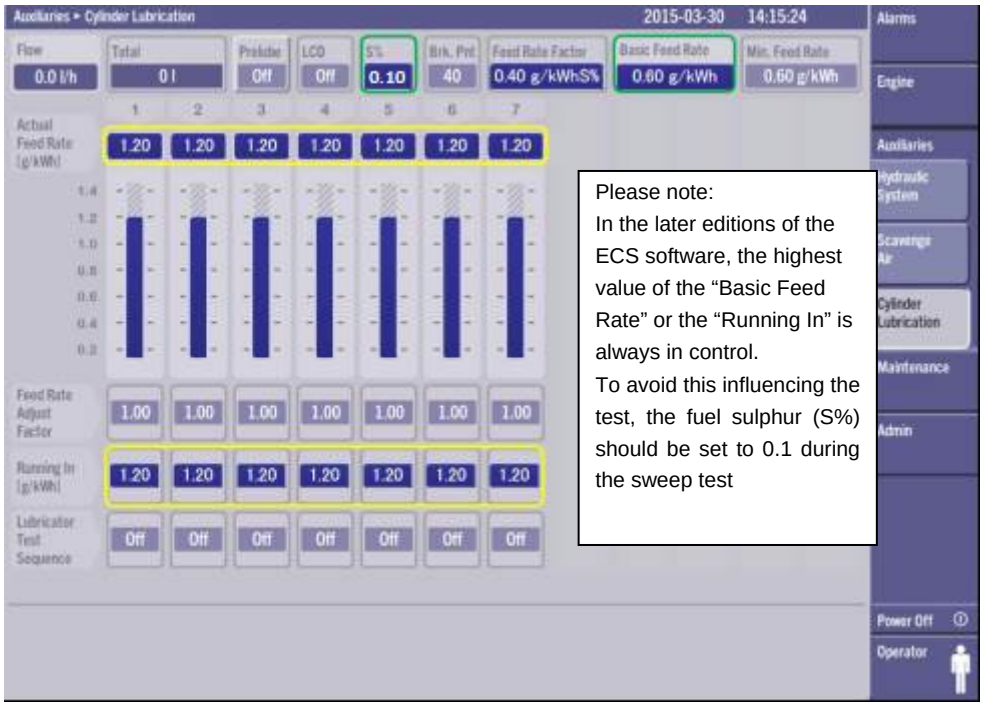


Figure 5. Day 2 of sweep test. The Running In mode is used and set to 1.2 g/kWh in this case the “Basic Feed Rate” is lower and the “Running In” is in control.

Day 3 Take drain oil samples from all cylinders after running for 24 h on a cylinder oil feed rate of 1.2 g/kWh. Sample-procedure same as Day 2. After this, the cylinder oil feed rate should be adjusted to 1.0 g/kWh

Day 4 Take drain oil samples from all cylinders after running for 24 h on a cylinder oil feed rate of 1.0 g/kWh. Sample-procedure same as Day 2.
After this, the cylinder oil feed rate should be adjusted to 0.8 g/kWh

Day 5 Take drain oil samples from all cylinders after running for 24 h on a cylinder oil feed rate of 0.8 g/kWh. Sample procedure same as Day 2. After this, the cylinder oil feed rate should be adjusted to 0.6 g/kWh

Day 6 Take drain oil samples from all cylinders after running for 24 h on a cylinder oil feed rate of 0.6 g/kWh. Sample-procedure same as Day 2.

When the last drain oil samples have been taken, the “Running In” setting is set to “Off” (0.00) to run in normal cylinder oil feed rate mode as shown in Figure 2. When results have come back and been analyzed, the suitable Feed Rate Factor can be calculated and used.

Important ! Make sure to set the Sulphur and Feed Rate Adjust Factor to actual value (set value before sweep test) when the sweep test is finished.

Sweep Test Protocol

Fill in the required information. Samples should be sent to a certified laboratory for analysis.

Check	Action	Tick if OK
Sample bottles	Use clean bottles and label them	
Fuel	Take sample or send in results from fuel analysis	
Fuel sulphur	Should be above 2.7%	
System Oil	Take a sample	
Cylinder oil	Take a sample of fresh unused oil	
MOP screen	Set feed rate of the cylinder oil. Follow fixed steps	
Load	Engine Control System (ECS) load setting to remain constant	
If Part Load Optimized	Setting to remain constant during entire test period	
Sweep Test Protocol	Fill in the form with the required information	
Performance sheet	Print the most recent updated performance sheet	
Drain oil samples	Take after 24 h running hours, before lowering feed rate	
On-board analysis equipment	If available: analyze BN and total iron	

Name of Ship:_____ IMO no:_____

Engine type:_____ Total running hours:_____

Load:_____

Exhaust Gas Bypass (EGB): Open/Closed?_____ *(Setting should remain constant during entire test period)*

Turbo Charger (TC) Cut-Out: Yes/No?_____ *(Setting should remain constant during entire test period)*

Name of cylinder oil:_____

BN:_____ SAE Viscosity:_____

Fuel Type:_____ Sulphur content fuel:_____%

Start date and time:_____ End date and time:_____

Please fill in the **Running Hours** for the following

Cylinder	1	2	3	4	5	6	7	8	9	10	11	12
Cylinder liners												
Piston crowns												
Piston rings												
Fuel valves												

Cylinder oil	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Feed rate (g/kWh)	1.4	1.2	1.0	0.8	0.6	Back to normal

Label the bottles with the following information:

1. Cylinder no.
2. Date
3. The name and BN of the cylinder oil
4. Feed rate of cylinder oil
5. Engine load

Please fill in this table when taking the samples

Cylinder		1	2	3	4	5	6	7	8	9	10	11	12
Day 2 Date	Feed rate												
	Engine load			Deck Temp℃				Humidity%					
Day 3 Date	Feed rate												
	Engine load			Deck temp℃				Humidity%					
Day 4 Date	Feed rate												
	Engine load			Deck temp℃				Humidity%					
Day 5 Date	Feed rate												
	Engine load			Deck temp℃				Humidity%					
Day 6 Date	Feed rate												
	Engine load			Deck temp℃				Humidity%					

To Send In	Tick if OK
Fuel sample or result from a fuel analysis	
System oil sample	
Fresh (unused) cylinder oil	
Drain oil samples	
Sweep Test Protocol filled in with all information	
Performance Sheet (the most recently updated)	

Evaluation of Sweep Test

The aim of the test is to show the correlation between the engine's corrosive behaviour and the lube oil's ability to counteract this. When the results from the sweep test are returned from the laboratory, the data need to be evaluated.

Calculating the actual ACC factor for a sweep test made on a load above the lubricator part-load breakpoint

During the sweep test, the load should be above the lubricator part-load breakpoint and the feed rate is set to fixed steps. The Feed Rate Factor (also called ACC factor) for each step can be calculated by dividing the feed rate step with the sulphur % of the fuel (Eq. 1).

$$\text{Feed Rate Factor}_{\text{Calculated}}(\text{g/kWh x S\%}) = \frac{\text{Feed rate (g/kWh)}}{\text{Fuel Sulphur (S\%)}} \qquad \text{(Eq.1)}$$

Example 1: Sulphur content of the fuel is 2.8%

$$\frac{1.4}{2.8} = 0.50 \text{ (g/kWh x S\%)}$$

Feed rate step (g/kWh)	Fuel Sulphur (S%)	Feed Rate factor $_{calcu}$ (g/kWh x S%)
1.4	2.8	0.50
1.2	2.8	0.43
1.0	2.8	0.36
0.8	2.8	0.28
0.6	2.8	0.21

END of Example 1

The Feed Rate Factor $_{calc}$ values are used to correlate the Fe and BN values in the samples. In Tables 1 and 2, you can fill in the Feed Rate Factor $_{calc}$ and the Fe and BN values. Two graphs can then be made where the Feed Rate Factor $_{calc}$ (FRF $_{calc}$) is the horizontal axis (x-axis) and the Fe values are the vertical axis (y-axis) in graph 1 and BN in graph 2. The Fe and BN can also be plotted in the same graph. Fe should be the left vertical axis and BN the right (view Figure 6 as an example).

Table 1. Write the Feed Rate Factor $_{calc}$ (FRF $_{calc}$) in the left column and the corresponding Fe value for each cylinder. These values are then used to make a graph in Excel.

Cylinder	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
FRF $_{calculated}$	Fe values											

Table 2. Write the Feed Rate Factor $_{calc}$ (FRF $_{calc}$) in the left column and the corresponding

BN value for each cylinder. These values are then used to make a graph in excel

Cylinder	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
FRF calculated	BN values											

Figure 6 illustrates how to evaluate a sweep test. In the normal case, the Fe concentration slowly rises until a point where it will rapidly increase. The acceptable Feed Rate Factor is found just before the rapid increase in Fe, in other words, before the Fe concentration reach the red area (Figure 5). A Feed Rate Factor that corresponds to acceptable Fe levels means that the corrosion is controlled. After the Feed Rate Factor is found, the corresponding BN value can be found. It indicates the possible level of BN depletion of the oil, which will not jeopardize the performance of the oil.

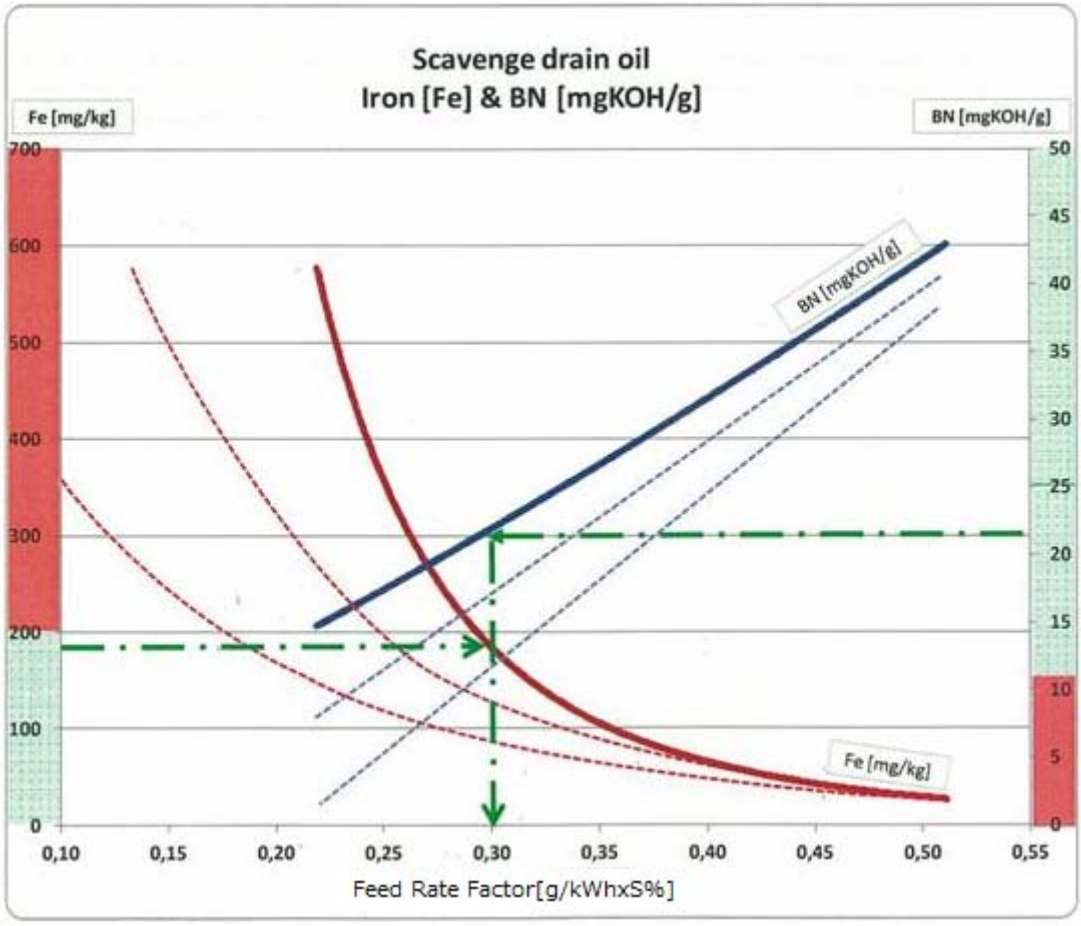


Figure 6. The Feed Rate Factor *(g/kWhxS%) is shown on the x-axis. The Fe concentration (mg/kg) is depicted with red lines and the result is read on the left y-axis. The axis is divided into three parts. The green bar shows safe operation condition, 0-200 Fe (mg/kg). When the Fe concentration exceeds 200 mg/kg (the red bar), the wear or corrosion starts to increase significantly, and the lube oil feed rate should also be increased.*

The rest BN concentration (mg KOH/g) is depicted with blue lines, and the result is read on the right y-axis. The axis is divided into two parts. The red bar (0-10 BN) means that the neutralization ability of lube oil has started to deplete and the risk of corrosion is increased. The green bar (10-50 BN) shows safe operation.

The thick blue line and the thick red line are the BN and Fe values from a sweep test. In order to find a suitable Feed Rate Factor, the procedure is as follows:

Follow the thick red line and find the Fe concentration for safe operation. In this example, it would be 200 because after this the slope of the thick red line increases rapidly. The corresponding Feed Rate Factor is found on the x-axis and, in this case, it is 0.30 g/(kWhxS%).

The rest-BN value, which corresponds to this safe operation, is found by using the BN curve (in this graph, the blue thick line) and reading the result of the right x-axis. In this case, the Feed Rate Factor 0.3 corresponds to 22 BN. The dashed lines are examples of what other sweep tests with other lube oils may look like.